Proton Plan
Booster Upgrades
Director's Review
August 23 – 24 2005

William Pellico

Projects

- ORBMP System *WBS 1.2.2*
  - Injection Scheme
  - Power Supply
- Booster Dump Relocation *WBS 1.2.11*
- Corrector System Upgrade *WBS 1.2.3*
- 30 Hz Harmonic Modification to GMPS *WBS 1.2.4*
- Gamma-t System Operation *WBS 1.2.5*
- Booster Chopper/Notcher *WBS 1.2.12*
- RF Modifications *WBS 1.2.9/1.2.13*
  - Drift Tube Cooling
  - RF hardware improvements – Bias, Modulators & Anode
  - Determination of Booster Rep Rate Limit & Reliability issues

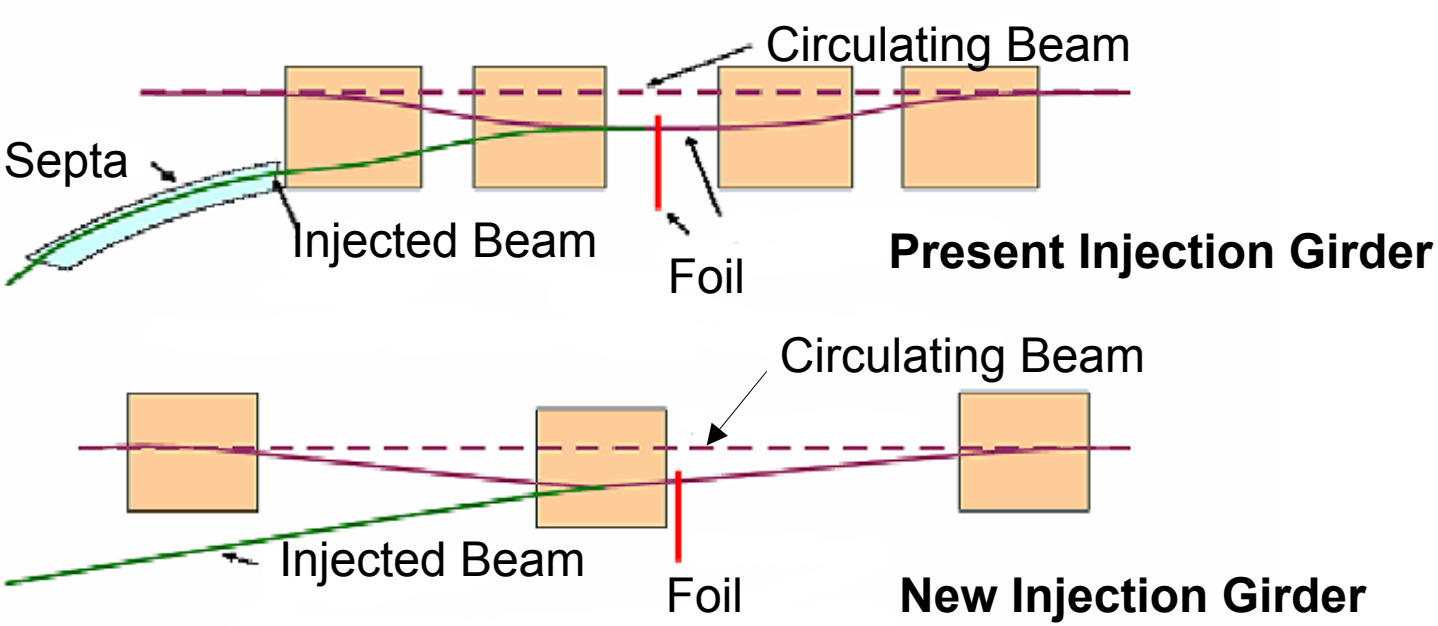
Booster Project Timetable

- Near Term – Upcoming Shutdown
  - ORBMP Power Supply, New Girder and Injection Layout
  - Booster Dump Relocation – Decommission L13 extraction
  - RF Drift Tube Cooling
- 2006 - (Depending upon shutdown schedule)
  - Baseline of Booster Chopper/Notcher
- 2007 - (Depending upon shutdown schedule)
  - Corrector Upgrade *
  - Baseline of 30 Hz modification
  - Baseline of gamma –t rework
  - Baseline of RF hardware
    - Solid State PA
      - Rework of Anode Supplies and Power Distribution
      - Bias and Modulator Supply Upgrades
- 2008 - (Depending upon shutdown schedule)
  - Corrector Upgrade

* Aggressive Schedule with late year shutdown

ORBMP/Injection - Next Shutdown

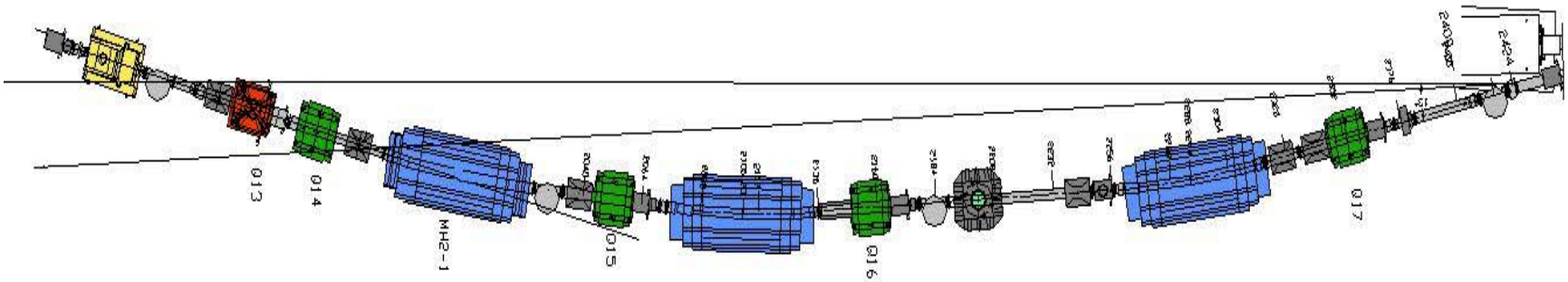
- New Booster Injection - ORBMP Girder & PS
  - A simplified 3 Bump injection scheme
    - Septa Magnet not required
    - Better Lattice Match
    - Alignment of Circulating beam with Injected beam
  - New ORBMP ps and magnets that can run at 15 Hz
    - Present system limited to 7.5 Hz due to heating



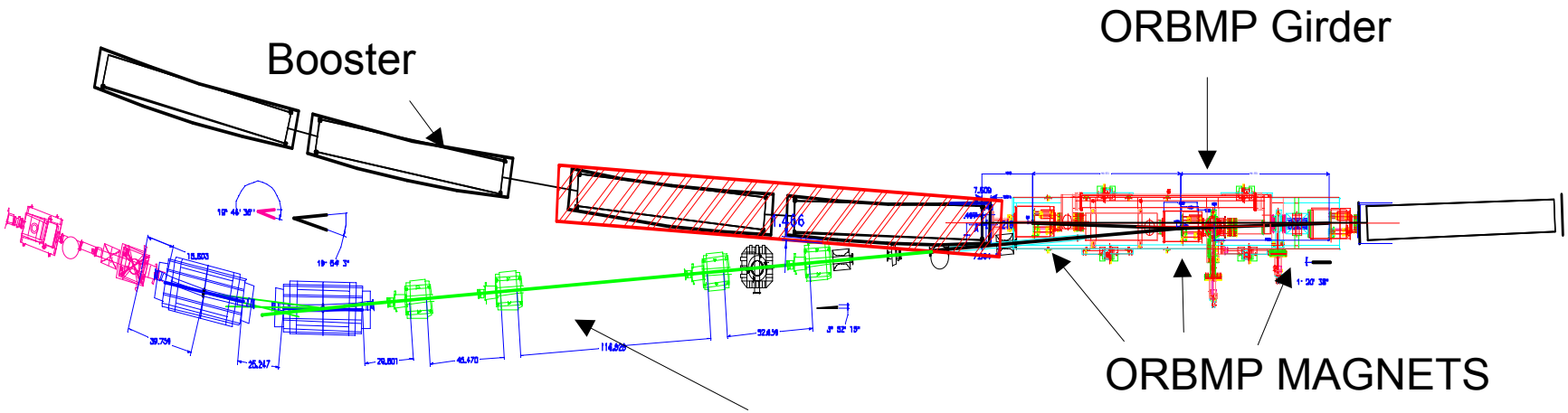
Provided by Jim Lackey and Fernanda Garcia

Injection Modifications – Next Shutdown

Current Scheme



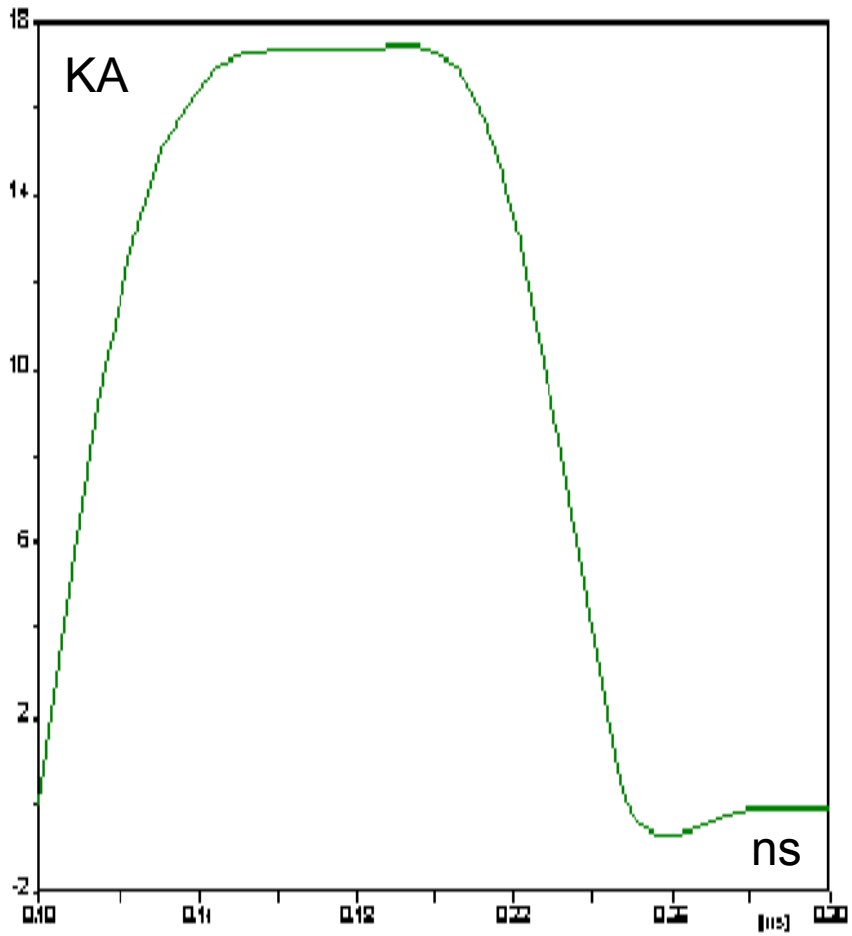
New Scheme



Provided by Jim Lackey and Fernanda Garcia

Orbump Power Supply - Requirements

- Nominal pulse amplitude = 15 kA
- Maximum pulse amplitude = 17.5 kA
- Maximum flat top duration = 50 μsec.
- Pulse flatness = ±0.5%
- Rise time
  - Minimum = 30 μsec.
  - Maximum = 40 μsec.
- Fall time
  - Minimum = 30 μsec.
  - Maximum = 40 μsec.
- Nominal repetition rate = 15 Hz
- Undershoot
  - Maximum amplitude = 5%
  - Minimum duration = 10 μsec.



Data Provided by Chez Jaoh

Management Structure

1. Proton Plan
Eric Prebys, Project Manager
Jeff Sims, Deputy

1.2 Booster Upgrades
(Bill Pellico)

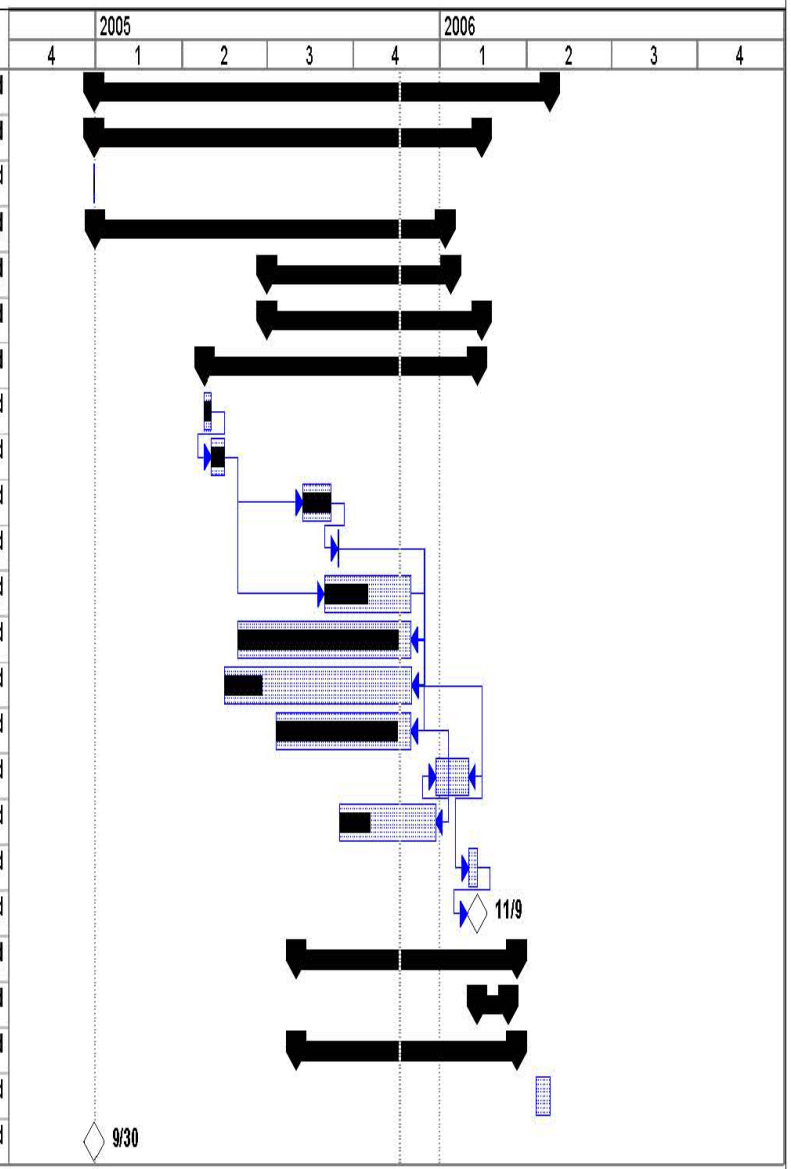
1.2.2 Orbump System
(Jim Lackey)

1.2.2.3 Orbump System Installation
(F.G. Garcia)

System Pre-Test	Orbump Instal.	400 MeV Reconf.
(J. Lackey)	(WBS 1.2.2.3.1) (F.G. Garcia)	(WBS 1.2.2.3.2) (F.G. Garcia)
Personnel		
AD Electrical Tech AD Mechanical Tech TD Electrical Tech TD Mechanical Tech	AD Electrical Tech AD Mechanical Tech PPD Survey Tech Contractor Tech	AD Electrical Tech AD Mechanical Tech PPD Survey Tech

Orbump Schedule

Uniq	WBS	Name	St	Fin	%	Float
10	**1.2.2**	**OrBump System**	**9/30/04**	**1/25/06**	**68%**	**623 d**
38	**1.2.2.1**	**OrBump System Magnets Design & Production**	**9/30/04**	**11/14/05**	**76%**	**12 d**
202	1.2.2.1.1	OrBump Magnet TD Division FY04 Costs	9/30/04	9/30/04	100%	0 d
139	**1.2.2.1.2**	**OrBump Magnets**	**10/1/04**	**10/6/05**	**85%**	**12 d**
142	**1.2.2.1.3**	**OrBump Stripline**	**4/1/05**	**10/12/05**	**59%**	**20 d**
146	**1.2.2.1.4**	**OrBump Girder**	**4/1/05**	**11/14/05**	**45%**	**12 d**
39	**1.2.2.2**	**OrBump System Power Supply**	**1/25/05**	**11/9/05**	**58%**	**32 d**
40	1.2.2.2.1	OrBump P.S. Specifications	1/25/05	1/31/05	100%	0 d
41	1.2.2.2.2	OrBump P.S. Simulations	2/1/05	2/14/05	100%	0 d
404	1.2.2.2.3	OrBump P.S. Design Review Preparation	5/9/05	6/7/05	100%	0 d
405	1.2.2.2.4	OrBump P.S. Design Review	6/15/05	6/15/05	100%	0 d
45	1.2.2.2.5	OrBump P.S. Cabinet Layout	6/1/05	8/31/05	50%	32 d
46	1.2.2.2.6	OrBump P.S. General Procurement	3/1/05	8/31/05	94%	32 d
42	1.2.2.2.7	OrBump P.S. Procure Capacitors	2/15/05	9/1/05	20%	63 d
44	1.2.2.2.8	OrBump Charging Power Supply Assembly	4/11/05	8/31/05	90%	32 d
47	1.2.2.2.9	OrBump P.S. Cabinet Assembly	9/27/05	10/31/05	0%	32 d
43	1.2.2.2.10	OrBump P.S. Assemble Controls	6/17/05	9/26/05	32%	32 d
278	1.2.2.2.11	OrBump P.S. Initial Testing	11/1/05	11/9/05	0%	32 d
309	1.2.2.2.12	OrBump Power Supply Ready for Installation	11/9/05	11/9/05	0%	32 d
342	**1.2.2.3**	**OrBump Syst Installation**	**5/2/05**	**12/21/05**	**56%**	**11 d**
175	**1.2.2.3.1**	**Installation**	**11/10/05**	**12/12/05**	**0%**	**15 d**
386	**1.2.2.3.2**	**400 MEV Line Reconfiguration**	**5/2/05**	**12/21/05**	**71%**	**11 d**
789	1.2.2.4	Commission OrBump System	1/11/06	1/25/06	0%	623 d
791	1.2.2.5	OrBump System Commissioned	9/30/04	9/30/04	0%	395 d



Orbump System Cost

Uniq	WBS	Name	Esc SWF	Esc M&S	Cont %
3	*1.2*	*Booster Upgrades*	*$2,910,891*	*$5,113,464*	*49%*
10	**1.2.2**	**Orbump System**	**$191,548**	**$130,635**	**29%**
38	**1.2.2.1**	**Orbump System Magnets Design & Production**	**$0**	**$0**	**0%**
39	**1.2.2.2**	**Orbump System Power Supply**	**$118,799**	**$122,000**	**28%**
342	**1.2.2.3**	**Orbump Syst Installation**	**$61,749**	**$8,635**	**32%**
789	**1.2.2.5**	**Commission Orbump System**	**$10,984**	**$0**	**40%**

Provided by Ken Domann

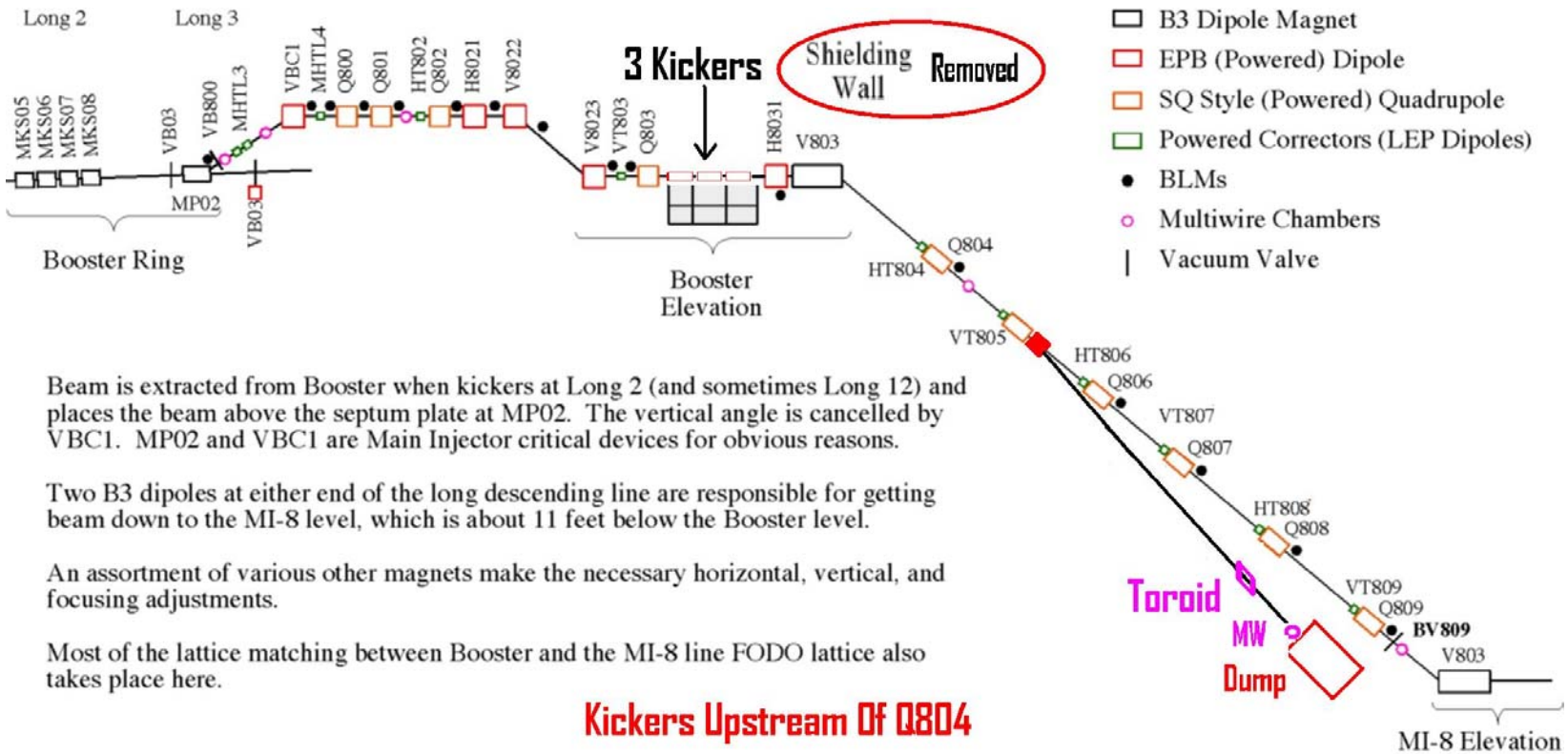
Booster Dump – Next Shutdown

- Relocation Of Booster Dump (sector Long 13)
  - Remove an Aperture Restriction
    - Low Energy Scraping (about 2-3 % efficiency)
  - Improve Booster Lattice Function
    - Edge Focusing removed when Doglegs off
  - Improve Booster Reliability
    - Kicker, Cables, Electronics, Caps etc Rad Damage/failure
  - Reduce Operational Tuning issues
    - Tuning of Bex bumps, Bump ratios, Losses, L13 septa removed, No L13 Dogleg bump, No L13 Orbit Bumps
  - Improved L3 extraction
    - Extra L12 Kicker – L13 aperture issue removed, Vertical Tune

Decommission L13 Extraction

- Clear out L13 Dump
  - Septa is moved up
    - Magnet will remain and allowed to cool down
  - Doglegs are turned off
    - Magnets will remain and allowed to cool down
  - Bex Bumps are turned off
  - Dump line BLM's, Toroid, BPM(?) will be moved to MI-8
    - Electronics will be moved to BWT
  - May reconfigure RDF radiation back to Booster
  - 3 Kickers at L12 will be moved to MI-8

Booster Dump – Layout



Beam is extracted from Booster when kickers at Long 2 (and sometimes Long 12) and places the beam above the septum plate at MP02. The vertical angle is cancelled by VBC1. MP02 and VBC1 are Main Injector critical devices for obvious reasons.

Two B3 dipoles at either end of the long descending line are responsible for getting beam down to the MI-8 level, which is about 11 feet below the Booster level.

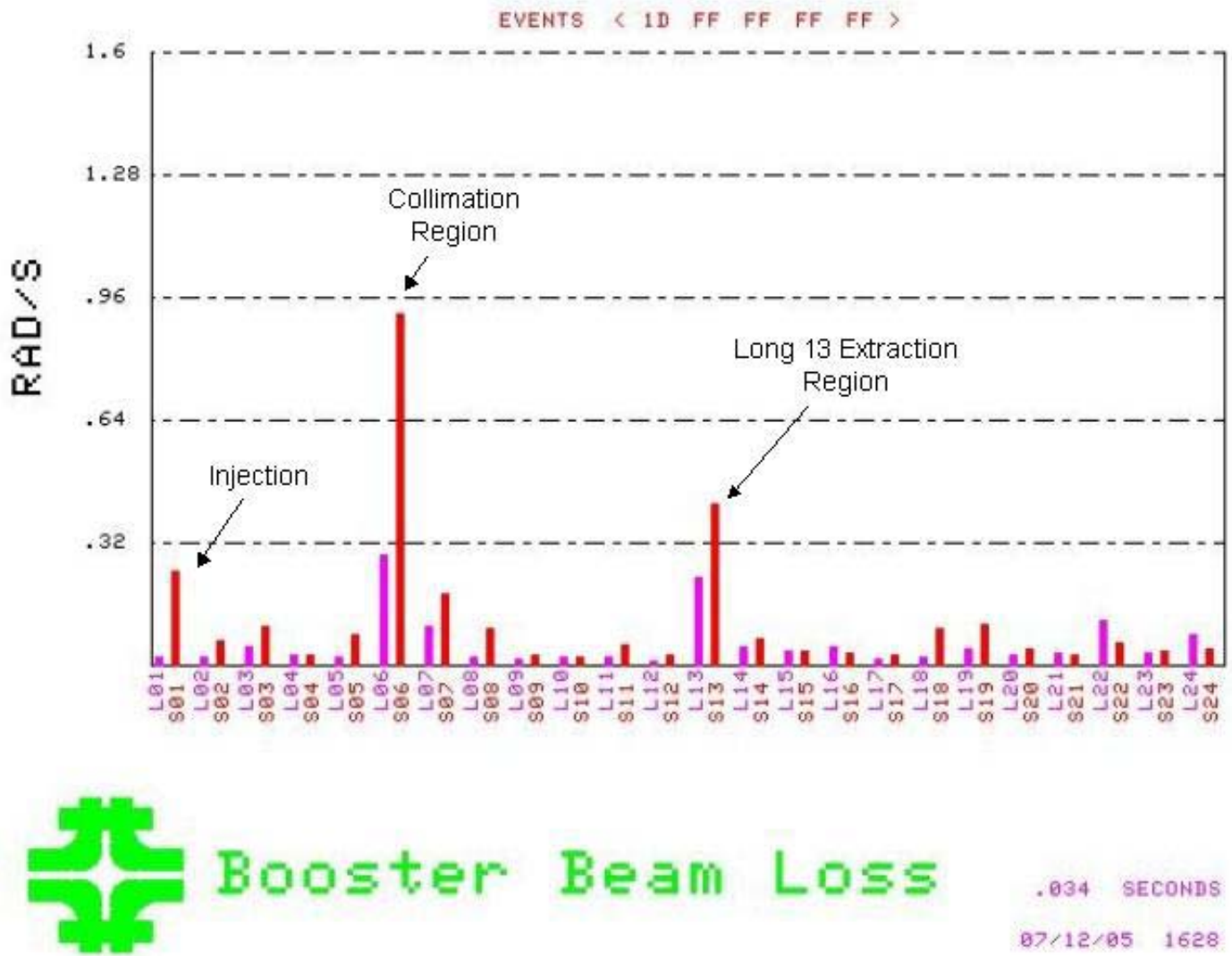
An assortment of various other magnets make the necessary horizontal, vertical, and focusing adjustments.

Most of the lattice matching between Booster and the MI-8 line FODO lattice also takes place here.

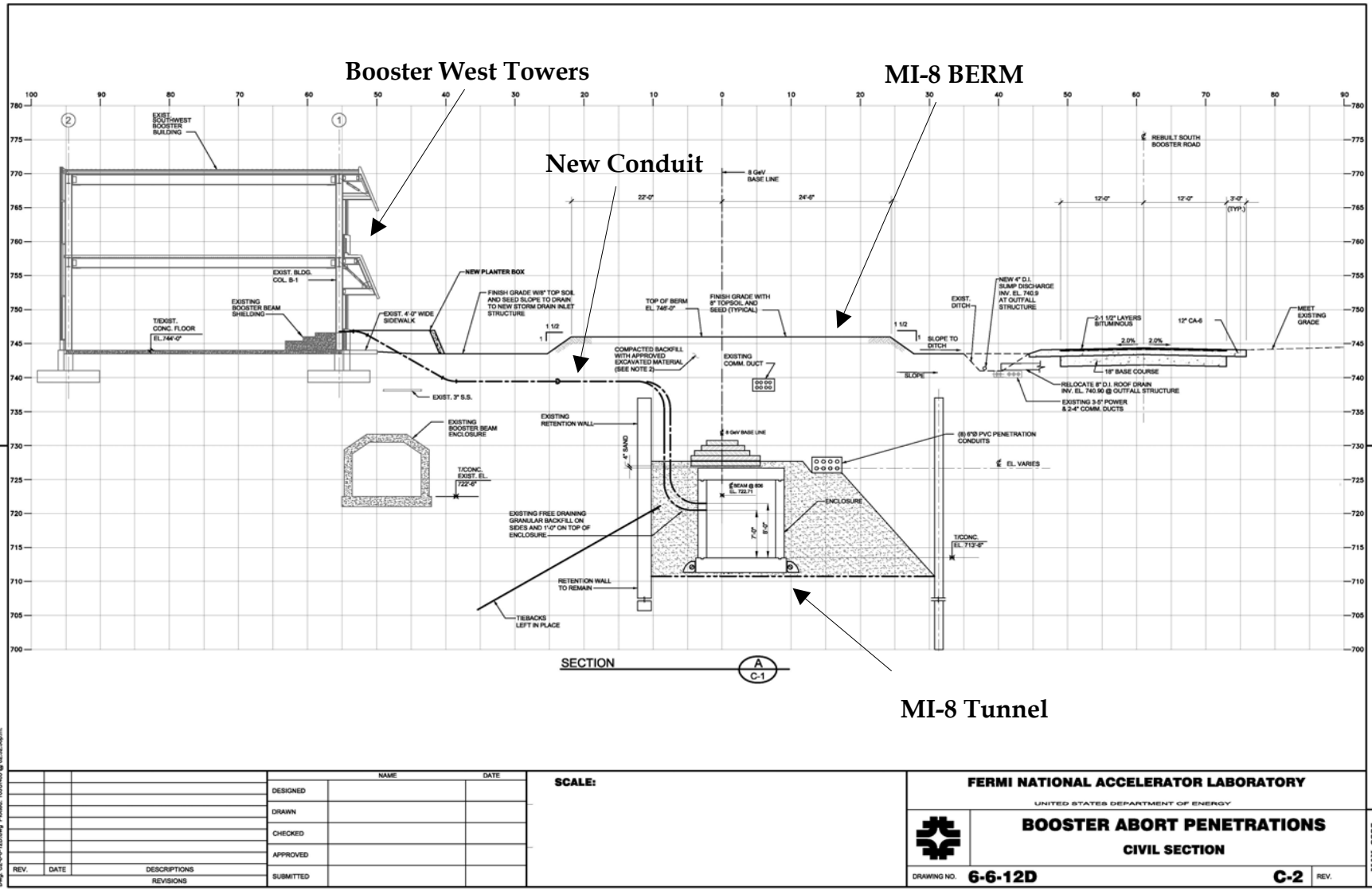
Kickers Upstream Of Q804

Vertical Profile of Upstream of MI-8 Line

Typical Beam Loss Profile



Tunnel View - Penetrations



REV.	DATE	DESCRIPTIONS
		REVISIONS

	NAME	DATE
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
SUBMITTED		

SCALE:

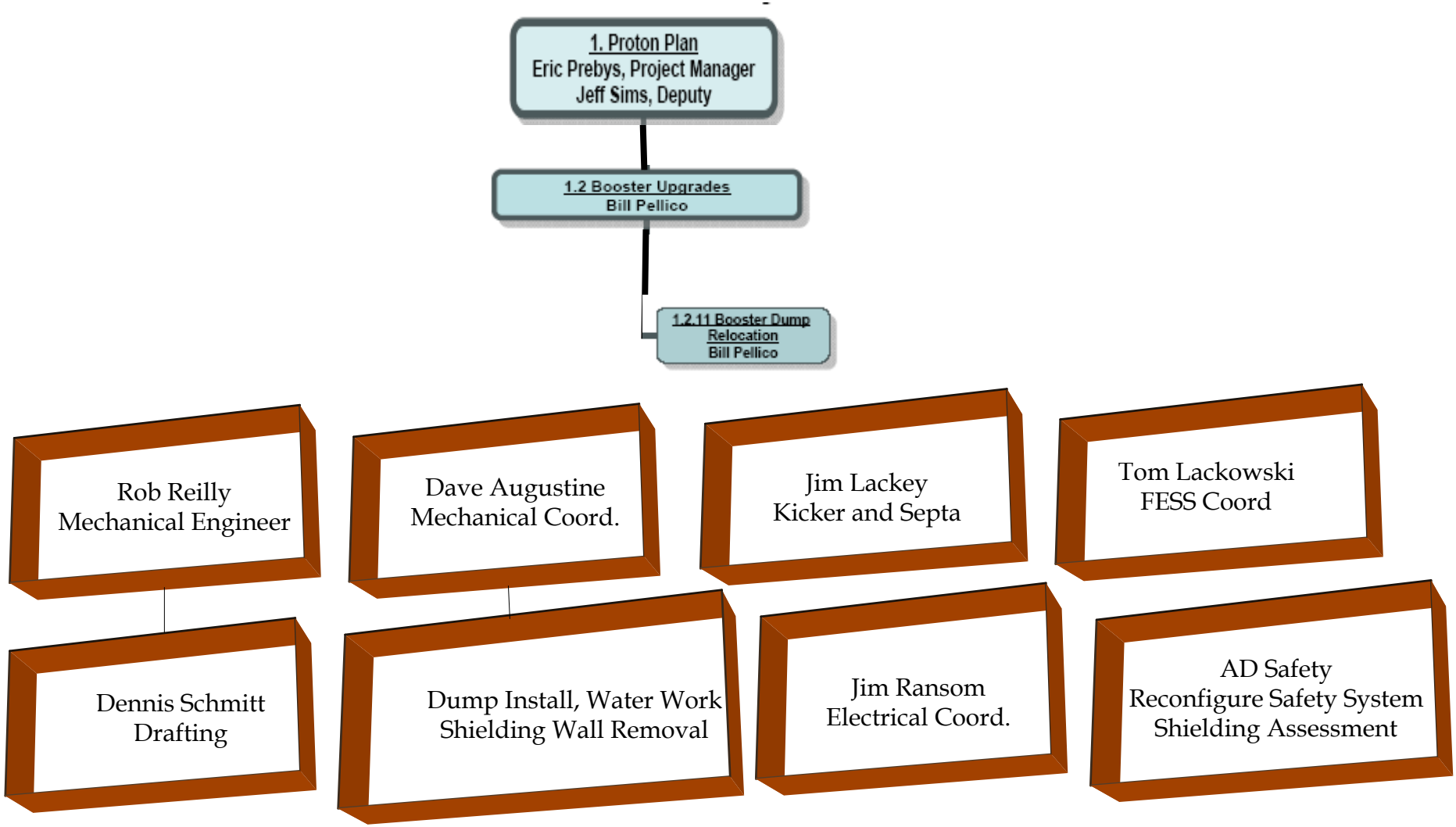
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

BOOSTER ABORT PENETRATIONS
CIVIL SECTION

DRAWING NO. 6-6-12D C-2 REV.

MAY, 2005

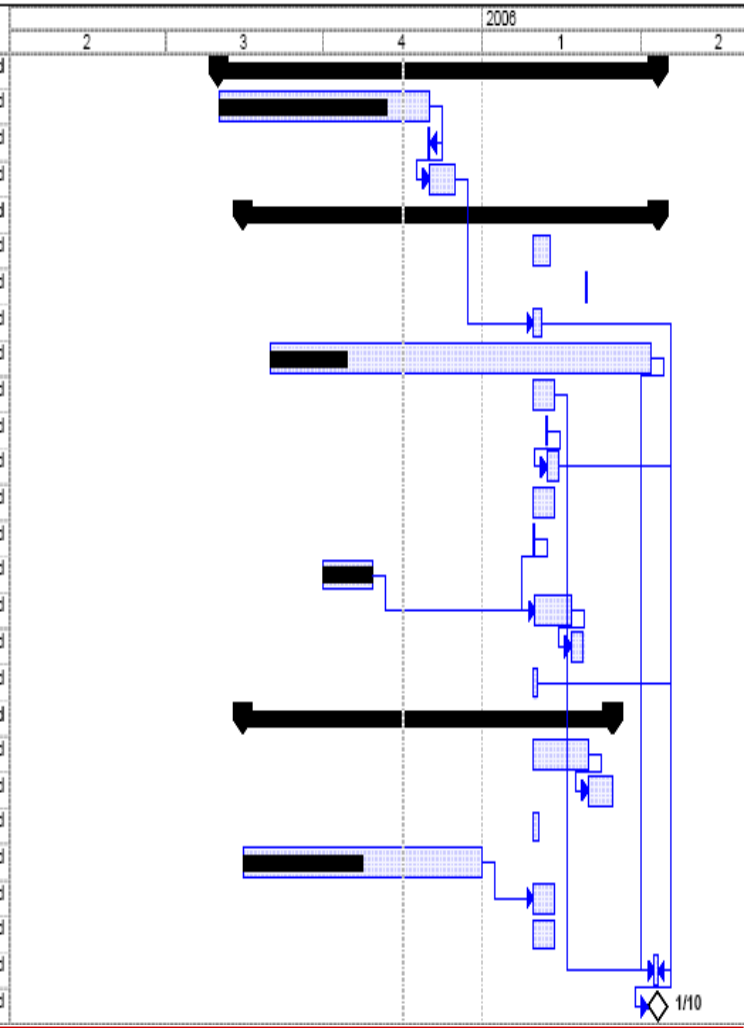
Management of Booster Dump Relocation



Booster Dump Relocation Schedule

Proton Plan
Booster Dump Relocation
Schedule Information

Uniq	WBS	Name	St	Fin	%	Float
284	**1.2.11**	**Booster Dump Relocation**	**5/2/05**	**1/10/06**	**35%**	**1 d**
286	1.2.11.1	Booster Dump Relocation Design	5/2/05	8/31/05	80%	73 d
427	1.2.11.2	Review Booster Dump Relocation Design	8/31/05	8/31/05	0%	73 d
288	1.2.11.3	Misc Fabrication	9/1/05	9/15/05	0%	73 d
287	**1.2.11.5**	**Booster Dump Relocation Install**	**5/16/05**	**1/10/06**	**26%**	**1 d**
730	1.2.11.5.1	Remove Shielding Wall	10/31/05	11/9/05	0%	39 d
289	1.2.11.5.2	Remove Existing MP01 Septum	11/30/05	11/30/05	0%	26 d
290	1.2.11.5.3	Install Replacement MP01 (Old MI-8) Septum	10/31/05	11/4/05	0%	42 d
383	1.2.11.5.4	Run Power to MP01 Septum	8/1/05	1/6/06	20%	1 d
384	1.2.11.5.5	Run Cooling Water to MP01	10/31/05	11/11/05	0%	35 d
291	1.2.11.5.6	Remove Booster Kickers	11/7/05	11/7/05	0%	36 d
292	1.2.11.5.7	Install Booster Kickers	11/8/05	11/14/05	0%	36 d
293	1.2.11.5.8	Relocate Power Supplies	10/31/05	11/11/05	0%	37 d
369	1.2.11.5.9	Remove Beam Pipe @Conduit Core Location	10/31/05	10/31/05	0%	28 d
803	1.2.11.5.10	Issue Request for Proposals on Conduit Construction	7/1/05	7/29/05	100%	0 d
294	1.2.11.5.11	Install Conduit	11/1/05	11/21/05	0%	28 d
368	1.2.11.5.12	Terminate/Splice Cables/Controls	11/22/05	11/28/05	0%	28 d
295	1.2.11.5.13	Install Dump	10/31/05	11/1/05	0%	45 d
296	**1.2.11.5.13**	**Radiation Safety Modifications**	**5/16/05**	**12/15/05**	**32%**	**15 d**
418	1.2.11.5.13.1	Install Dump Switch for V803	10/31/05	12/1/05	0%	15 d
419	1.2.11.5.13.2	Pull Cables for V803	12/2/05	12/15/05	0%	15 d
788	1.2.11.5.13.3	Installation of Beam Dump	10/31/05	11/2/05	0%	44 d
420	1.2.11.5.13.4	Beam Stop Design/Fabrication	5/16/05	9/30/05	50%	57 d
421	1.2.11.5.13.5	Install Beam Stop	10/31/05	11/11/05	0%	37 d
422	1.2.11.5.13.6	Recable Interlock Chassis & Test	10/31/05	11/11/05	0%	37 d
297	1.2.11.5.14	Alignment	1/9/06	1/10/06	0%	1 d
322	1.2.11.5.15	Booster Dump Relocation Installation Complete	1/10/06	1/10/06	0%	1 d



Booster Dump Relocation Cost

Uniq	WBS	Name	Esc SWF	Esc M&S	Cont %
284	**1.2.11**	**Booster Dump Relocation**	**$69,343**	**$251,146**	**40%**
286	1.2.11.1	Booster Dump Relocation Design	$20,444	$11,000	40%
427	1.2.11.2	Review Booster Dump Relocation Design	$0	$0	0%
288	1.2.11.3	Misc Fabrication	$0	$10,000	40%
287	**1.2.11.5**	**Booster Dump Relocation Install**	**$48,899**	**$230,146**	**40%**
730	1.2.11.5.1	Remove Shielding Wall	$0	$42,148	40%
289	1.2.11.5.2	Remove Existing MP01 Septum	$852	$0	40%
290	1.2.11.5.3	Install Replacement MP01 (Old MI-8) Septum	$4,260	$0	40%
383	1.2.11.5.4	Run Power to MP01 Septum	$0	$12,150	40%
384	1.2.11.5.5	Run Cooling Water to MP01	$0	$4,112	40%
291	1.2.11.5.6	Remove Booster Kickers	$852	$0	40%
292	1.2.11.5.7	Install Booster Kickers	$4,260	$0	40%
293	1.2.11.5.8	Relocate Power Supplies	$11,360	$0	40%
369	1.2.11.5.9	Remove Beam Pipe @Conduit Core Location	$568	$0	40%
803	1.2.11.5.10	Issue Request for Proposals on Conduit Construction	$0	$100,000	0%
294	1.2.11.5.11	Install Conduit	$4,352	$30,840	10%
368	1.2.11.5.12	Terminate/Splice Cables/Controls	$2,556	$0	40%
295	1.2.11.5.13	Install Dump	$2,272	$7,196	40%
296	**1.2.11.5.13**	**Radiation Safety Modifications**	**$17,568**	**$33,700**	**40%**
418	1.2.11.5.13.1	Install Dump Switch for V803	$852	$10,280	40%
419	1.2.11.5.13.2	Pull Cables for V803	$11,604	$4,112	40%
788	1.2.11.5.13.3	Installation of Beam Dump	$0	$7,196	40%
420	1.2.11.5.13.4	Beam Stop Design/Fabrication	$0	$8,000	40%
421	1.2.11.5.13.5	Install Beam Stop	$852	$2,056	40%
422	1.2.11.5.13.6	Recable Interlock Chassis & Test	$4,260	$2,056	40%
297	1.2.11.5.14	Alignment	$0	$0	0%
322	1.2.11.5.15	Booster Dump Relocation Installation Complete	$0	$0	0%

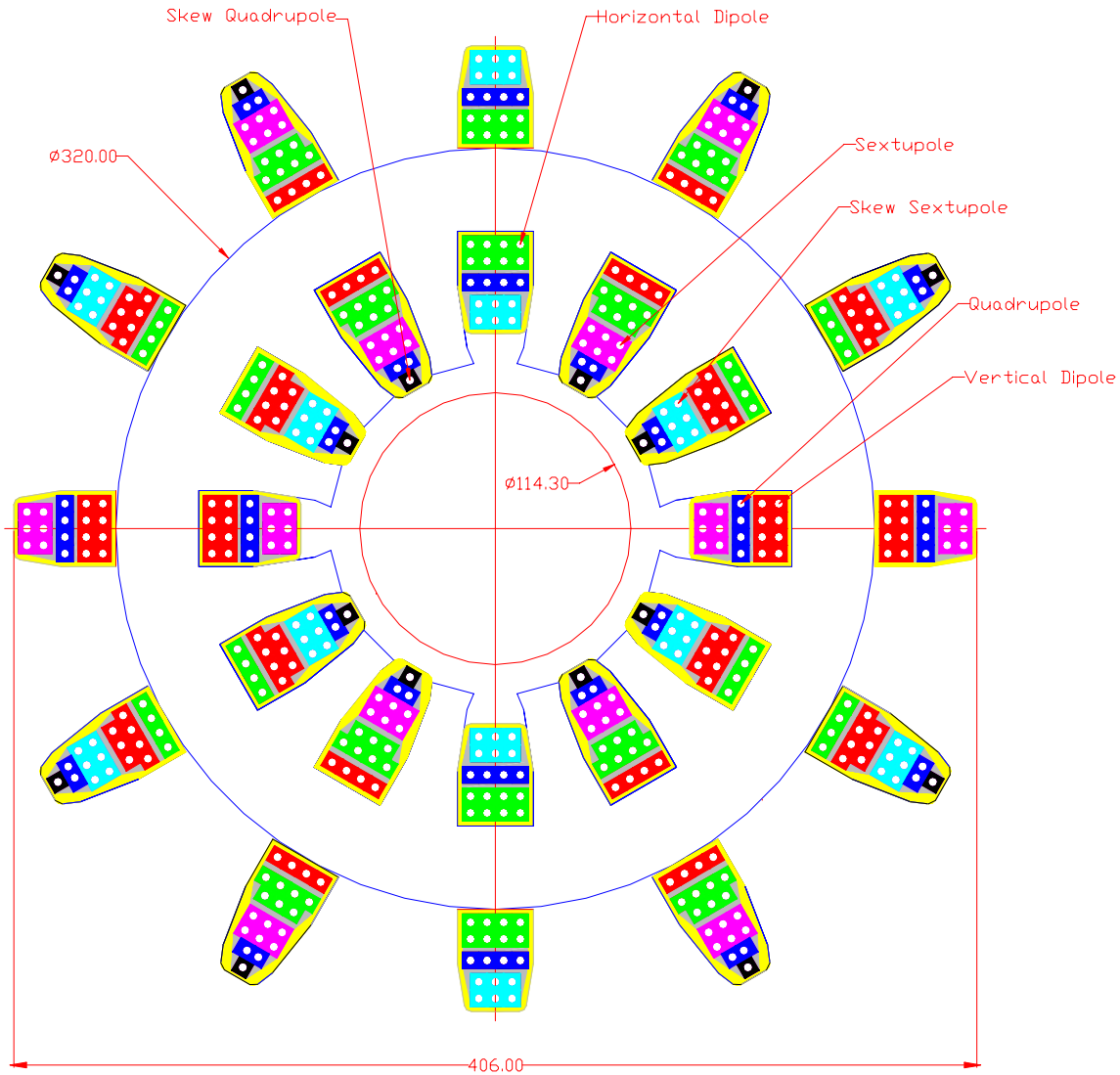
Booster Corrector (Shutdown Dependent '07)

- Booster Corrector Upgrade
  - Goals
    - Horizontal and Vertical Position Control through cycle
    - Horizontal and Vertical Tune Control through cycle
    - Horizontal and Vertical Chromaticity Control through cycle
  - Booster Corrector Hardware
    - New combined function magnets
    - Rewiring of power distribution
    - New power supplies
    - New correction package support girder
    - Utilities – cooling water
    - Controls – firmware and software
    - Gallery space – rack issues
  - Issues
    - Gradient requirements – Desired Tune Shift
    - Power Supply Operating points
    - Schedule – A lot of complicated magnets to build and test!

E. Prebys, C. Drennan, D. Harding

Booster Corrector Design

E. Prebys, C. Drennan, D. Harding



Management of Corrector Projects

- Manpower: People Doing the Work

(Those who have assisted so far with estimates and design work, that I can remember and those I expect help from during the project)

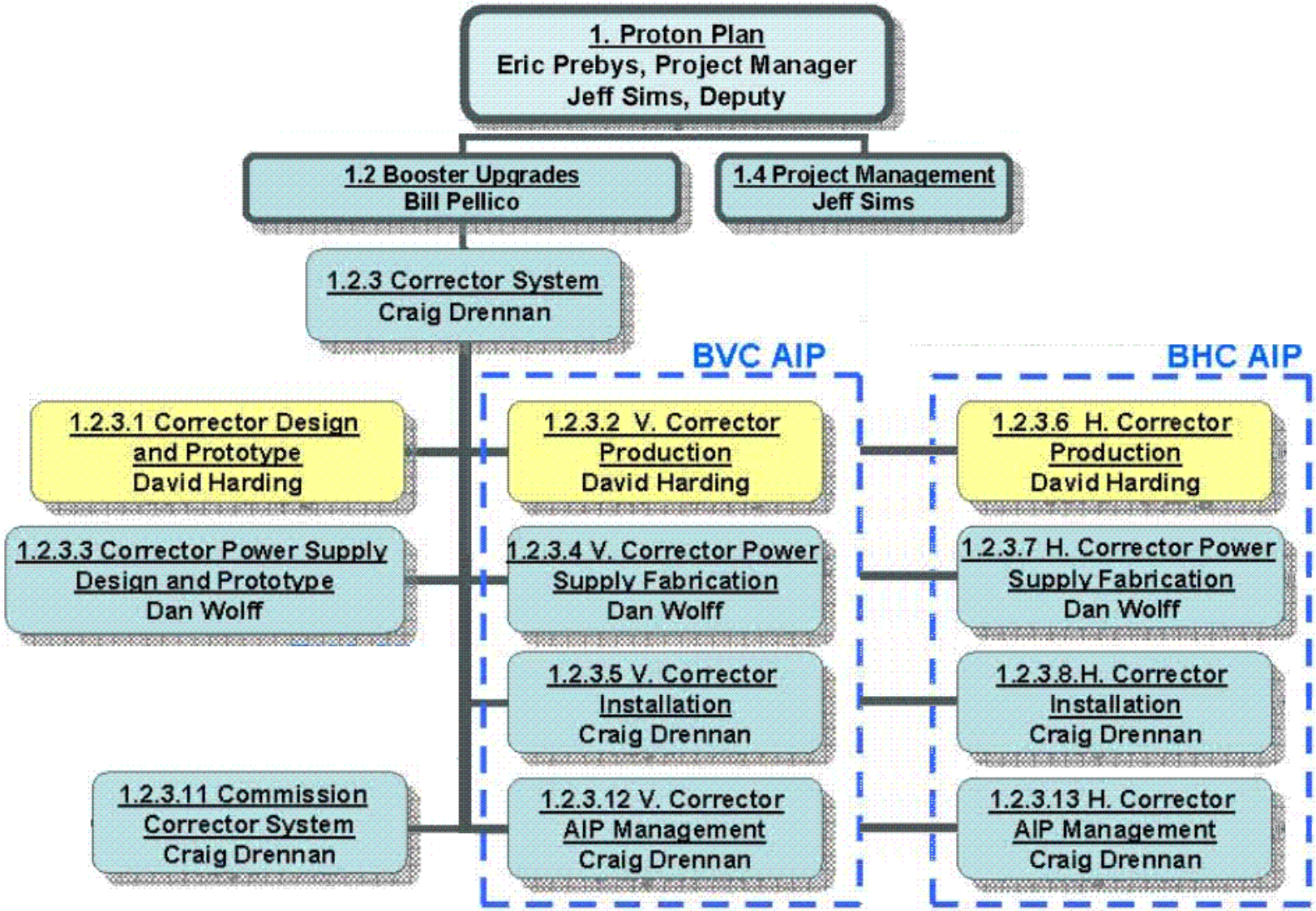
- Corrector System Specification
  - AD – BS PROTON SOURCE
  - Jim Lackey, Bill Pellico, Eric Prebys, Dave Harding (TD)
- Corrector Package Design, Prototyping and Evaluation
  - TD - ENGINEERING & FABRICATION
  - Dave Harding, TJ Gardner, Andrew Makarov, Vladimir Kashikhin
- Corrector Package Fabrication
  - Outside Manufacturer
- Building Power Supply Racks, Cable Termination, Controls Installation
  - AD-BS PROTON SOURCE
  - Craig Drennan, design and oversight
  - Doris Dick, Andrew Feld, Jeff Larson, Rich Meadowcroft
- Magnet Cooling Water Installation
  - AD-AS-MECHANICAL SUPPORT DEPT
  - Maurice Ball, et.al.
- New Magnet Supports and Long / Short Straight Spool Piece Designs
  - AD-AS-MECHANICAL SUPPORT DEPT
  - Joel Misek, Robert Reilly, et.al.

E. Prebys, C. Drennan, D. Harding

Management of Corrector Projects (Cont.)

- Power Supplies/Amplifiers Design, Prototyping and Evaluation.
  - AD-AS-ELECTRICAL/ELECTRONIC SUPPORT
  - Dan Wolff, et.al.
- Power Amplifier Fabrication
  - Outside Manufacturer
- CAMAC Power Supply Controllers
  - AD-ACCELERATOR CONTROLS DEPT
  - Allen Franck, et.al.
- Pulling of Power and Control Cables
  - AD-BE-ENGINEERING SUPPORT
  - James Ranson, Estimates and Oversight
  - Contract Electricians

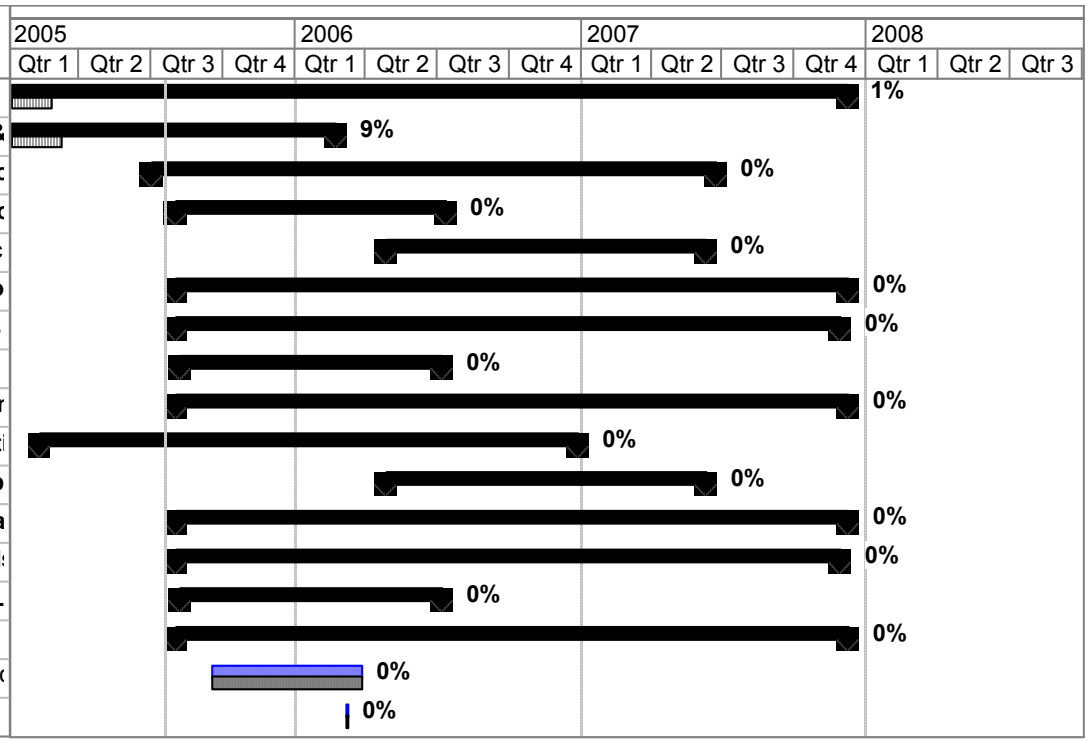
Management of Corrector Projects



Corrector Schedule

- Schedule (detailed Gantt chart available)

ID	WBS	Task Name
104	1.2.3	Corrector System
105	1.2.3.1	Corrector Magnets Design &
112	1.2.3.2	Vert Corr Magnets Productic
123	1.2.3.3	Corrector PS Design & Protc
165	1.2.3.4	Verticle Corrector PS Fabric
174	1.2.3.5	Verticle Corrector Installatio
175	1.2.3.5	Vert Corr PS & Controls
205	1.2.3.5	Vert Corr Cabling, CBL
215	1.2.3.5	Vert Corrector Magnet Ir
238	1.2.3.6	Horiz Corr Magnets Producti
249	1.2.3.7	Horizontal Corrector PS Fab
258	1.2.3.8	Horizontal Corrector Installa
259	1.2.3.8	Horiz Corr PS & Control
289	1.2.3.8	Horiz Corr Cabling, CBL
299	1.2.3.8	Horiz Corrector Magnet
323	1.2.3.9	Corrector Magnets Spares Acc
324	1.2.3.1	Review Booster Modifications



- Critical path
  - Power supply procurement and installation (still 60 days of float)
  - Magnets themselves (Breakout - Prebys talk)

E. Prebys, C. Drennan, D. Harding

Corrector Upgrade Cost

Uniq	WBS	Name	Start	Finish	%Esc/Burd	Labor	Esc M&S	Cont %
11	1.2.3	Corrector System (Magnets Only)	1/4/05	12/7/07	1%	$693,197	$990,791	N/A
74	1.2.3.1	Corrector Magnets Dsgn & Prototype	1/4/05	2/20/06	9%	$87,405	$65,000	N/A
75	1.2.3.2	Vert Corr Magnets Production	7/1/05	6/21/07	0%	$315,562	$479,943	N/A
339	1.2.3.2.1	Vert Corr Magnets Dsgn & Proc	7/1/05	12/27/06	0%	$21,732	$69,801	N/A
340	1.2.3.2.2	Vert Corrector Magnets Fab & Test	4/20/06	6/21/07	0%	$280,780	$370,179	N/A
687	1.2.3.6	Horiz Corrector Magnets Production	2/8/05	12/27/06	0%	$290,230	$445,848	N/A
688	1.2.3.6.1	Horiz Corrector Magnets Dsgn & Proc	7/1/05	12/27/06	0%	$21,710	$87,251	N/A
693	1.2.3.6.2	Horiz Corrector Magnets Fab & Test	2/8/05	6/2/06	0%	$268,520	$358,597	N/A

Planning and Spares Cost

Uniq	WBS	Name	Esc SWF	Esc M&S	Cont%
769	1.2.3.10	Vert Corr AIP Project Management	$44,453	$0	40%
770	1.2.3.11	Horiz Corr AIP Project Management	$36,282	$0	40%
762	1.2.3.12	Prepare AIP Documentation	$27,567	$0	40%
784	1.2.3.13	Corrector System Technical Review	$0	$0	0%
763	1.2.3.14	Corrector AIPs Approved	$0	$0	0%
729	1.2.3.15	Review Booster Modifications Design	$0	$0	0%
785	1.2.3.16	Corrector System Installation Review	$0	$0	0%
728	1.2.3.17	Corrector Magnets Spares Account (12 spares)	$147,822	$179,475	40%

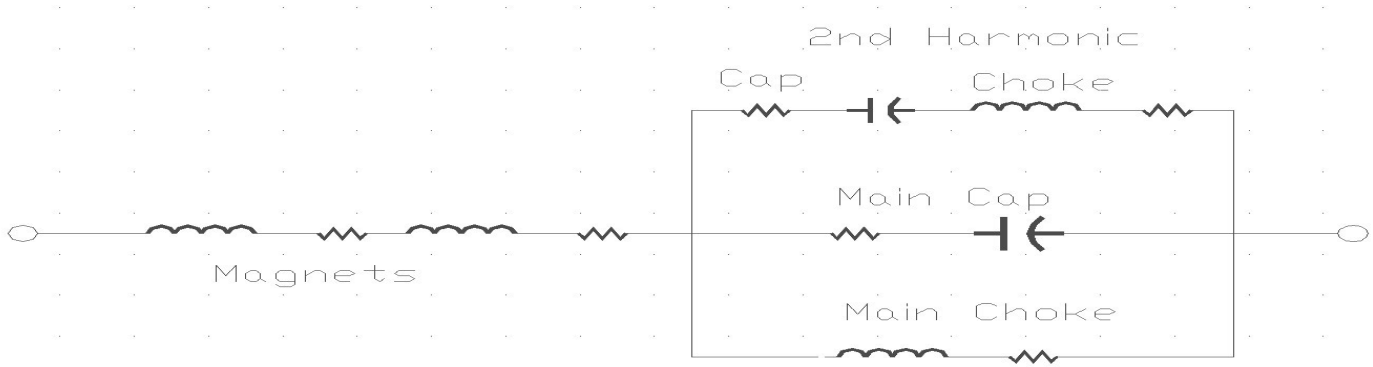
E. Prebys, C. Drennan, D. Harding

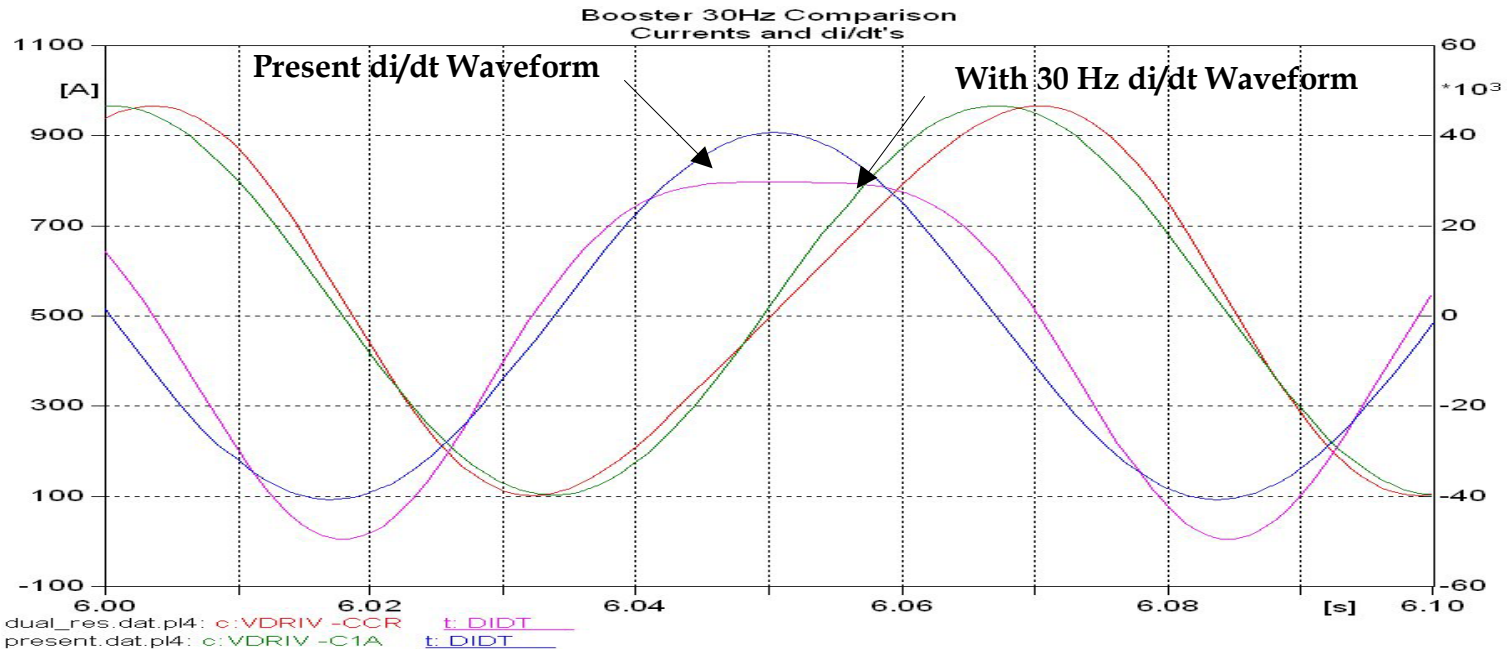
30 Hertz Harmonic - GMPS WBS 1.2.4

- The purpose is to decrease the maximum dE/dt in booster magnets and thus increase the RF capability (bucket area)
- Goal is to keep present magnets, chokes, and capacitors.
- Add additional components as necessary
  - Power Supply Changes
    - Power supplies need to invert
    - All 4 existing power supplies will be needed for normal operation.
    - Possible modifications to PS passive filter.
    - New second harmonic cap bank is needed.
    - New second harmonic choke is needed.
    - New regulation system needs to be developed.
- Analysis still ongoing
  - Simulations by Xi Yang and J. MacLachlan
    - Recent Simulations Look Promising
- Power Supply constraints will need to be considered
  - New setup will require all supplies to be on (only 3 needed now)
  - Voltage to ground will be higher
- Issues with transition and instabilities need to be studied

D. Wolff, J Maclachlan,Xi Yang

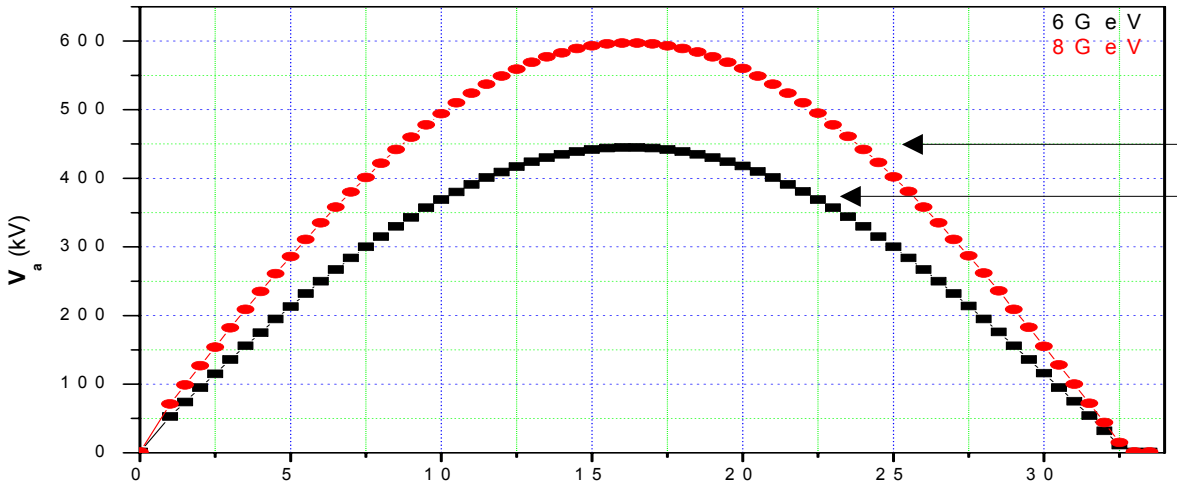
GMPS Girder Modifications



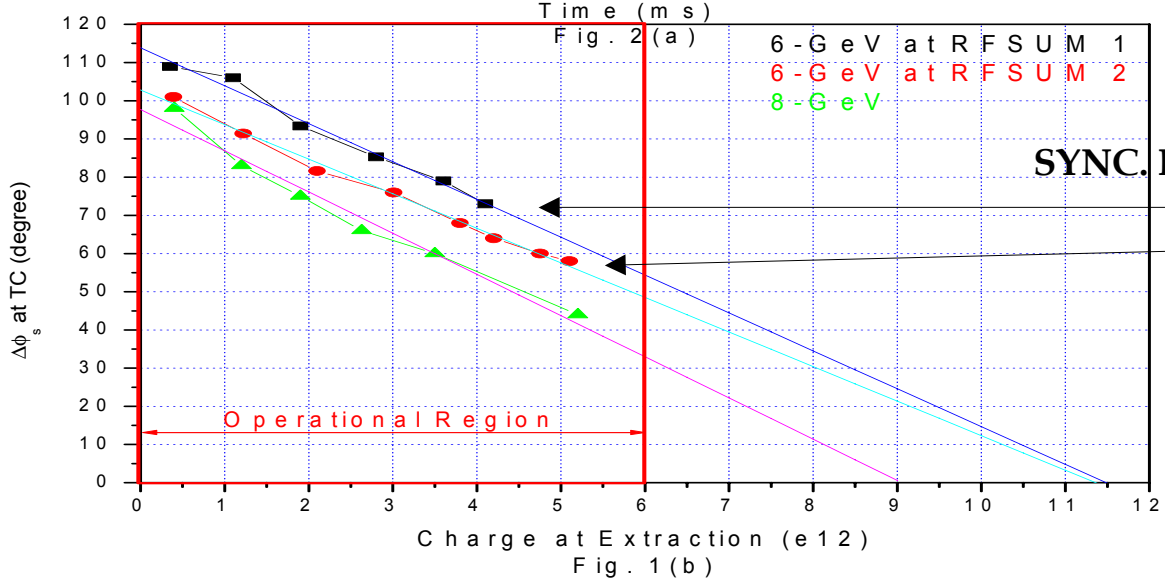


D. Wolff, J Maclachlan,Xi Yang

RF voltage and phase comparisons



Required Voltage
15 Hz GMPS
15 + 30 Hz GMPS



SYNC. Phase at Transition
15 Hz
15 + 30 Hz

D. Wolff, J Maclachlan,Xi Yang

Cost of 30 Hz Modifications

D. Wolff, J Maclachlan,Xi Yang

Cost Summary (FY05 M&S):

Prototype (E4R):		$50k
Chokes (quote soon):	$11k ea.	$550k
Capacitors (quote received):	$7k/girder	$350k
Misc.:	$2.2k/girder	$110k

Labor Summary:

Prototype:	Monthly, 1.5MY	Weekly, 1.0MY
Production:	Monthly, .75MY	Weekly, 1.0MY

279	**1.2.4.1**	**30 Hz Harmonic Prototype**	**$360,378**	**$50,258**	**40%**
234	1.2.4.1.1	GMPS Modification	$200,357	$0	**40%**
214	1.2.4.1.2	30 Hz Harmonic Prototype	$125,393	$50,258	**40%**
426	1.2.4.1.3	Review 30 Hz Harmonic Prototype	$0	$0	**0%**
233	1.2.4.1.4	30 Hz Harmonic Project Decision	$0	$0	**0%**
230	1.2.4.1.5	30Hz Girder Design	$34,627	$0	**40%**
280	**1.2.4.2**	**30 Hz Harmonic Production**	**$241,270**	**$1,034,168**	**40%**
232	1.2.4.2.1	30Hz Procurement	$1,741	$953,984	**40%**
333	1.2.4.2.2	30Hz Delivery	$0	$0	**0%**
231	1.2.4.2.3	30Hz Installation	$239,529	$80,184	**40%**
316	1.2.4.2.4	30Hz Installation Complete	$0	$0	**0%**

Gamma – t Project WBS 1.2.5

- The Gamma –t jump in Booster will need to be removed for the corrector upgrade
  - Magnets need to be removed to allow new corrector installation
    - Magnets have high activation levels
- Need to study/simulate usefulness of Gamma – t crossing
  - A decision to keep or remove Gamma – t based on studies
    - New Magnets would be designed to fit with new corrector
    - Present Gamma –t magnets were not designed for present Booster operation conditions
    - Understand effect on operations like cogging
- A new power supply will need to be designed and built

J Maclachlan,Xi Yang

Booster Chopper/Notcher WBS 1.2.12

- A chopper like device that can be used to both notch the beam and possibly as an extraction 'kicker'
  - As a notcher it will allow for cycle dependent notch lengths
    - A shorter notch will reduce losses on non cogged cycles
  - A electrostatic chopper is significant faster than a magnetic kicker
    - A faster rise/fall time will reduce losses from partially kicked bunches
  - An electrostatic chopper is fairly inexpensive
    - Estimated Cost $200,000 to $300,000
  - An electrostatic chopper will fit in Booster at several locations
  - The power supply for an electrostatic chopper is similar to our present kicker supplies
- The new chopper can be based on our present 400 MeV chopper

Booster RF *WBS 1.2.9/1.2.13*

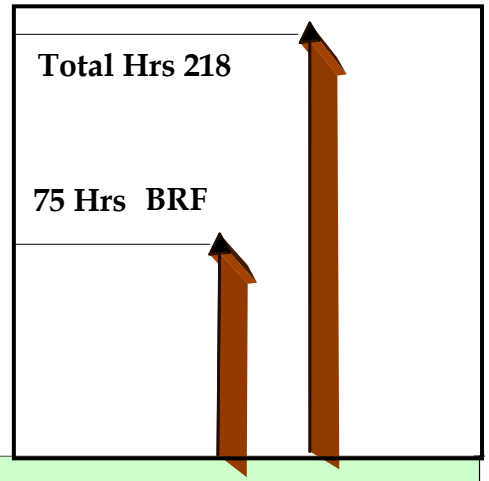
- RF Modifications
  - Drift Tube Cooling
    - Plan is connect up cooling during 2005 fall shutdown
      - The Booster cavities tuner cone cooling (once used) will be reconnected.
      - The increased cooling will allow 8 - 9 Hz operation (tuner only.)
- Determination of Booster Rep Rate Limit & Reliability issues ***(Bob Ducar and John Reid have been assessing RF limits)***
  - Upgrade West Gallery Bias Supply Transformers
    - West Gallery Bias supplies may not be capable of > 10Hz
      - » East Gallery Supplies are larger and can run at 15 Hz
  - RF hardware – Modulators
    - Dec Power Supply upgrade
      - Dec PS is old and frequently the cause of downtime – looking for drop in replacement
  - Anode Supplies/Yard power
    - The yard transformers are not believed to be capable of 15 Hz operation
      - Increased monitoring and studies recommended
      - Possibly update 30 year old supplies
  - Gallery Cooling is inadequate for > ~10 Hz operation
    - Gallery water pressure is a concern and is being investigated

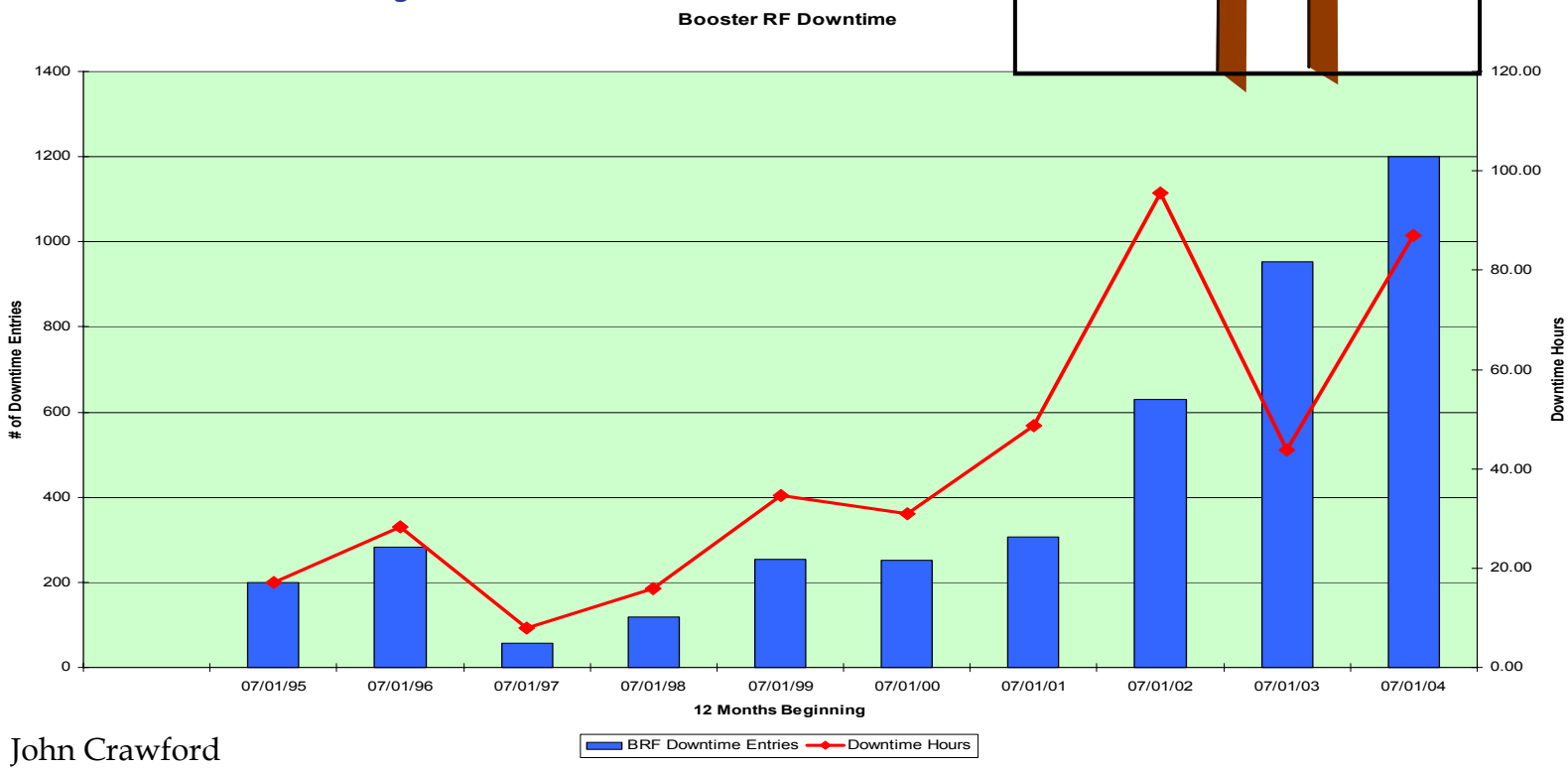
Booster Rate Goals

Rate	Limits	Reason	Solution	Time Table
Present Rate 7.3	Orbmp - PS,Magnets	Heating	New Supply New Magnets	Fall 2005
8 Hz	RF Tuner Cone & Drift Tube Cooling	Heating	LCW connect	Fall 2005
9 - 10 Hz	West Gallery Bias Supplies	Heating	New Transformers	
> 10 Hz	Gallery LCW	Low pressure	Additional pumping	
To 15 Hz	Anode Supplies	Transformer	New Supplies	
To 15 Hz	RF AC Power	Transformer Issues	New Transformers	

RF Reliability

- Gathering Statistics on Booster RF failure
  - RF Power Amps
    - Solid State Amps – Like Main Injector
  - Modulators
    - As Mentioned
  - Bias Supplies
    - As Mentioned
  - Anode Supplies
    - As Mentioned
  - Misc – Rad damage to Cables





John Crawford

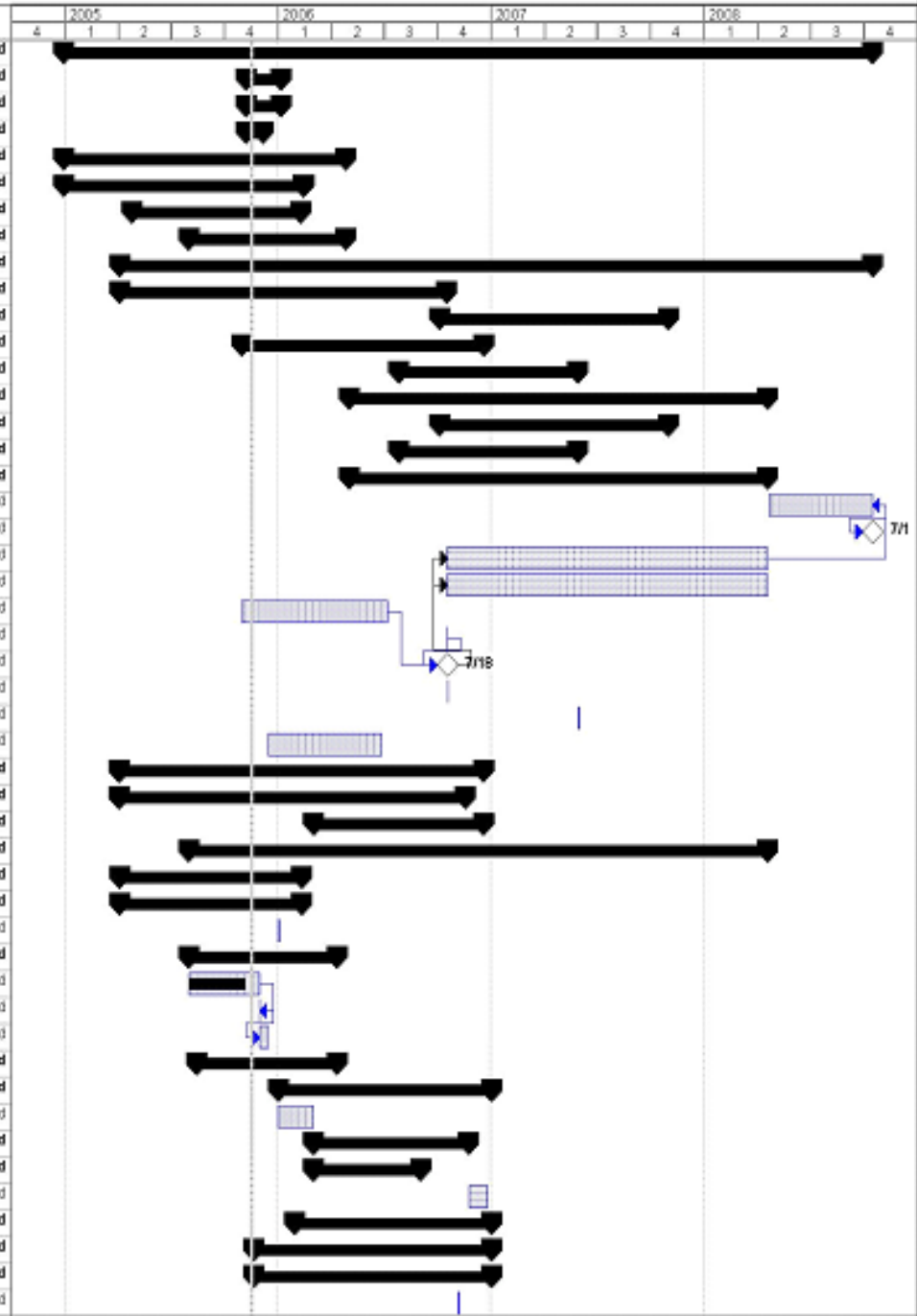
Booster RF Reliability

- Booster RF reliability remains a major concern
  - 18 RF stations (+19th large aperture prototype)
  - Original, 35 year old technology
  - All 18 required for optimum operation (vital for slip stacking)
  - Typically down one station 10-15% of the time.
- Considering proposed solid state upgrade to power amplifiers
  - Would improve situation considerably, but not solve all of our problems.
  - Cost: ~$7M
  - Time: ~2 years
- In the short term
  - Replace 19th prototype cavity with ordinary cavity
    - Will have at least 18 cavities >95% of the time
  - Work with RF Department and Operations to implement a maintenance and refurbishment program
    - Allocating ~$500K in the plan (WBS 1.2.13)
- Will make a decision regarding the solid state upgrade within the next six months.

(See related talks by Ducar and Prebys)

Booster Upgrades
Schedule Information

Uniq	WBS	Name	St	Fin	%	Float
3	**1.2**	**Booster Upgrades**	**9/30/04**	**7/15/08**	**17%**	**0 d**
737	**1.2.1**	**Booster RF Duty Cycle Limits & Means of Improving Booster RF Reli**	**8/8/05**	**10/6/05**	**0%**	**66 d**
732	**1.2.1.1**	**Feasibility of Booster RF Operating @ 9Hz**	**8/8/05**	**10/6/05**	**0%**	**66 d**
736	**1.2.1.2**	**Strategies for Improving Booster RF Reliability @ 9Hz**	**8/8/05**	**9/6/05**	**0%**	**78 d**
10	**1.2.2**	**OrBump System**	**9/30/04**	**1/25/06**	**68%**	**67 d**
38	**1.2.2.1**	**OrBump System Magnets Design & Production**	**9/30/04**	**11/14/05**	**76%**	**12 d**
39	**1.2.2.2**	**OrBump System Power Supply**	**1/25/05**	**11/6/05**	**58%**	**32 d**
342	**1.2.2.3**	**OrBump Syst Installation**	**5/2/05**	**1/25/06**	**51%**	**67 d**
11	**1.2.3**	**Corrector System**	**1/4/05**	**7/15/08**	**2%**	**0 d**
74	**1.2.3.1**	**Corrector Magnets Design & Prototype**	**1/4/05**	**7/17/06**	**16%**	**147 d**
75	**1.2.3.2**	**Vert Corr Magnets Production**	**7/6/06**	**6/1/07**	**0%**	**91 d**
469	**1.2.3.3**	**Corrector PS Design & Prototype**	**6/1/06**	**9/19/06**	**0%**	**7 d**
511	**1.2.3.4**	**Verticle Corrector PS Fabrication**	**4/27/06**	**2/27/07**	**0%**	**104 d**
520	**1.2.3.5**	**Verticle Corrector Installation**	**2/1/06**	**1/15/08**	**0%**	**0 d**
687	**1.2.3.6**	**Horiz Corr Magnets Production**	**7/6/06**	**6/1/07**	**0%**	**91 d**
599	**1.2.3.7**	**Horizontal Corrector PS Fabrication**	**4/27/06**	**2/27/07**	**0%**	**104 d**
608	**1.2.3.8**	**Horizontal Corrector Installation**	**2/1/06**	**1/15/08**	**0%**	**0 d**
768	1.2.3.9	Commission Corrector System	1/22/08	7/15/08	0%	0 d
801	1.2.3.10	Corrector System Complete	7/15/08	7/15/08	0%	0 d
769	1.2.3.10	Vert Corr AIP Project Management	7/19/06	1/15/08	0%	125 d
770	1.2.3.11	Horiz Corr AIP Project Management	7/19/06	1/15/08	0%	125 d
762	1.2.3.12	Prepare AIP Documentation	6/1/05	4/7/06	0%	70 d
784	1.2.3.13	Corrector System Technical Review	7/18/06	7/18/06	0%	0 d
763	1.2.3.14	Corrector AIPs Approved	7/18/06	7/18/06	0%	0 d
729	1.2.3.15	Review Booster Modifications Design	7/20/06	7/20/06	0%	297 d
785	1.2.3.16	Corrector System Installation Review	3/1/07	3/1/07	0%	347 d
728	1.2.3.17	Corrector Magnets Spares Account (12 spares)	9/16/05	3/27/06	0%	580 d
12	**1.2.4**	**30 Hz Harmonic**	**1/3/05**	**9/18/06**	**34%**	**10 d**
279	**1.2.4.1**	**30 Hz Harmonic Prototype**	**1/3/05**	**6/18/06**	**44%**	**30 d**
280	**1.2.4.2**	**30 Hz Harmonic Production**	**12/2/05**	**9/18/06**	**0%**	**10 d**
13	**1.2.5**	**Gamma-t System**	**5/2/05**	**1/15/08**	**12%**	**125 d**
15	**1.2.7**	**Booster RF Cavity Cooling**	**1/4/05**	**11/11/05**	**80%**	**17 d**
157	**1.2.7.1**	**Stainless Steel Flex Tubes**	**1/4/05**	**11/11/05**	**80%**	**17 d**
782	1.2.9	Booster Solid State RF Upgrade	10/3/05	10/3/05	0%	698 d
284	**1.2.11**	**Booster Dump Relocation**	**5/2/05**	**1/10/06**	**35%**	**1 d**
286	1.2.11.1	Booster Dump Relocation Design	5/2/05	8/31/05	80%	73 d
427	1.2.11.2	Review Booster Dump Relocation Design	8/31/05	8/31/05	0%	73 d
288	1.2.11.3	Misc Fabrication	9/1/05	9/15/05	0%	73 d
287	**1.2.11.5**	**Booster Dump Relocation Install**	**5/16/05**	**1/10/06**	**36%**	**1 d**
285	**1.2.12**	**Booster Chopper**	**10/3/05**	**10/2/06**	**0%**	**0 d**
372	1.2.12.1	Specify Booster Chopper	10/3/05	12/1/05	0%	0 d
797	**1.2.12.2**	**Booster Chopper Device**	**12/2/05**	**8/24/06**	**0%**	**0 d**
793	**1.2.12.3**	**Booster Chopper PS**	**12/2/05**	**6/2/06**	**0%**	**68 d**
376	1.2.12.4	Test Booster Chopper w/Power Supply	8/25/06	9/25/06	0%	0 d
377	**1.2.12.5**	**Booster Chopper Installation**	**10/31/06**	**10/2/06**	**0%**	**0 d**
438	**1.2.13**	**Booster RF Reliability Improvements**	**8/22/06**	**10/2/06**	**0%**	**0 d**
731	**1.2.13.1**	**Booster AC Pulsed Power Transformer Replacement**	**8/22/06**	**10/2/06**	**0%**	**0 d**
747	1.2.13.2	Booster RF Equip Upgrades to Improve Reliability	8/7/06	8/7/06	0%	39 d



Booster Upgrade Summary

- Near Term Projects
  - Well Scoped and on schedule – Will allow Booster to run ~9 Hz
    - Dump Relocation
    - Orbump – Booster Injection
    - RF Cavity Cooling
- 2006 Projects
  - Finish simulations – begin design
    - Booster Chopper
- 2007 - 2008 Projects
  - Large Projects – Shutdown Schedule Dependent
    - Booster Corrector Upgrade
      - Aggressive Schedule
    - 30 Hz Harmonic
      - More Simulations - Studies
    - Gamma – T
      - More Simulations - Studies
    - Booster RF
      - Investigating Options vs Cost